Volume 26 August, 1940 *Number 8*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Hoisting Machinery and
Heavy Duty Materials
Handling

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

TEXACO LUBRICANTS

FOR MATERIALS HOISTING AND HANDLING EQUIPMENT

Electric Cranes, Ore Bridges, Unloaders, Car Dumpers, Power Shovels, Lifts, etc.

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DIESEL ENGINES (See Texaco Lubrication Chart for American Diesels and other Oil Engines.)	

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Hoisting Machinery and Heavy Duty Materials Handling

MASS production has led to many perfections in the handling of materials. It was sponsored by the automotive industry, when the production line became the factor behind low cost output. Iron and steel contributed; likewise ceramics and textiles, but petroleum kept the necessary machinery running, by the development of the essential lubricants.

Since then, materials hoisting has become a problem in many other industries; in fact, it exists wherever raw materials, such as ore, coal, or rock must be mined; where the plant must move heavy iron or steel castings, and when the final product must be handled for shipping or storage. Conventional machinery has been perfected to this end. The principles behind steam shovel design contributed to the modern gasoline and Diesel-driven power shovel; likewise, the capacity of the crane was extended. Aside from these, the ore unloader and skip hoist became indispensable to blast furnace operation.

There are many similarities in the construction of these machines, though they differ markedly in appearance. All these similarities interest the petroleum industry as they involve mechanisms requiring lubrication. They include bearings, gears, wire rope, and the power unit. As the loads to be handled are extreme, these elements must be built in proportion.

Coupled with the machine designer's efforts to build for load-carrying capacity and the development of lubricants which will afford adequate protection, the lubricant equipment engineer has perfected a variety of methods for automatic application of both oils and greases. It has been a happy combination, for maintenance costs have been reduced, and production is rarely interrupted. One must not be misled, however, by the massive nature of many of the moving parts; the operator should realize that wear can occur quite as rapidly as on much smaller parts, if lubrication is not properly maintained. Larger contact areas are involved, and under the load conditions, it may be proportionately more difficult to develop the necessary lubricating films.

In addition, we must consider the weather conditions. Very frequently materials hoisting machinery must function throughout the year exposed to the elements, and without any provision for heat protection in cold weather. Frequently production requirements will be most severe when operating conditions are worst, for the output of the plant must not be retarded. When a production schedule has been established, storage yard conditions must not interfere in any way.

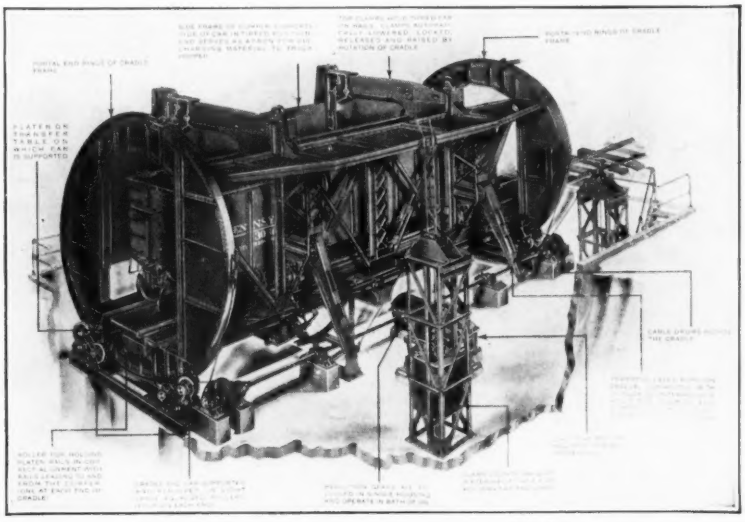
THE MACHINERY INVOLVED

Power Shovels and Hoisting Engines

Power shovels are customarily referred to as being of the revolving or railroad type. The principles of operation of both are similar, although the former is intended for lighter work, such as would be encountered on building excavations and stripping jobs in mining, etc.; the latter is adapted to more severe service, such as in railroad construction, stone quarry, and plant service.

The design involves a revolving frame or turntable which carries the hoisting boom or

shovel arm, the engines, and other operating mechanism. A suitable carrying frame or truck may be equipped with standard railroad wheels, or mounted on a truck fitted with broad traction wheels of the trackless type, or a caterpillar unit. In most instances, the machine is self-propelling. The revolving frame is carried on roller bearings or cone rollers, which travel on a suitable swing-gear casting securely attached to the truck frame.



Courtesy of Link-Belt Company

Fig. 1—Details of a Link-Belt rotary railroad car dumper, showing the operating mechanisms. Careful lubrication of the equalized rollers is especially important.

Hoisting engines, as used on the various types of steam-power shovels or hoists, may be either of the vertical or the horizontal type, receiving their steam from a locomotive type or upright boiler located on the turntable. This assembly swings with the turntable, being mounted on a rigid base, and securely bolted to the main revolving casting to overcome vibration. Gasoline, kerosine, or Diesel engines can be as readily installed, to supplant steam.

Three distinct engines are required for the efficient operation of a power shovel; i. e., a hoisting engine which controls the rise and fall of the shovel or dipper; a swing engine for the revolving of the turntable; and a thrust or crowd engine to operate the shovel in the process of digging or initial moving of the materials. While many builders install all these engines on the turntable itself, there are some who locate the thrust or crowd engine on the boom.

The Electric Crane

This unit is a vital factor in practically every industry where bulky materials or products must be moved with precision and rapidity. It is a predominating machine in the iron and steel industry, from the ore pile to the shipping department. Visualize the ladle crane for handling molten metals; the ingot stripping crane which removes ingots from their moulds; the ingot charging crane used in connection with the soaking or heating pits; the cranes which charge the open-hearth furnaces; and those which transfer steel plates and shapes from cooling racks to storage, and thence to cars or boats for shipping.

Crane service is perhaps the most varied of any materials handling equipment. The ore bridge and power shovel hoist may be continually exposed to the elements; detrimental conditions, to be true, but capable of more or less standardization from the viewpoint of lubrication, for it is known in advance that ice, snow, hail, and rain must be often encountered. So lubricants are selected accordingly, especially for parts which may not be entirely housed. In crane service, however, the charging crane in an open hearth or soaking pit building may be subjected to abnormally high radiated heat. Meanwhile, the overhead traveling crane in the storage yard may be exposed to the same conditions as the ore bridge.

So standardization of crane lubrication is often difficult. In other words, conditions cannot be averaged. To many variables are involved. Where one crane may operate under cover in an atmospheric temperature of 100 degrees Fahr., directly adjacent there may be a similar device in the yard, operating exposed to the weather. It is fair to neither to attempt to standardize bearing, gear, or wire rope lubricants to serve them both. Certain of the wearing elements of one or the other will be bound to suffer.

This is particularly true in cold weather when marked temperature differences may be involved. Bearing lubrication, for example, under such conditions, on an outdoor crane will require oils of low pour test and comparatively low viscosity to insure the maintenance of an effective lubricating film, and the reduction of the possibility of congealment in the oil reservoirs. In effect, an oil of approximately 200 to 300 seconds Sayboit viscosity at 100 degrees Fahr. would be required. An oil of similar nature should be used in grease manufacture when a lubricant of this type is necessary.

Other mechanisms which must be considered likewise include an assemblage of electric motors, gears, and wire ropes. The principles of operation are essentially the same on all types of cranes. In brief, the electric motors move the crane proper, the trolley along the bridge, and rotate the hoisting drums. The gears serve to bring about the necessary speed reductions. Bearings are required to carry the gear and pinion shafts, trolley-wheel journals, and motor armatures. Wire ropes or cables are essential for actual hoisting of the grab buckets, hooks, or electromagnets which serve to carry the materials to be handled.

Coal Handling

Coal handling in the medium and larger sized plants, from the main storage yard or railroad siding to the boiler plant bunkers can be accomplished by means of the skip hoist for elevating, or by a crane or power shovel, according to the area of the storage yard. Auxiliary cars can also be used where one-level handling is required. These often form a part of the tramrail conveying or weighing larry assembly.

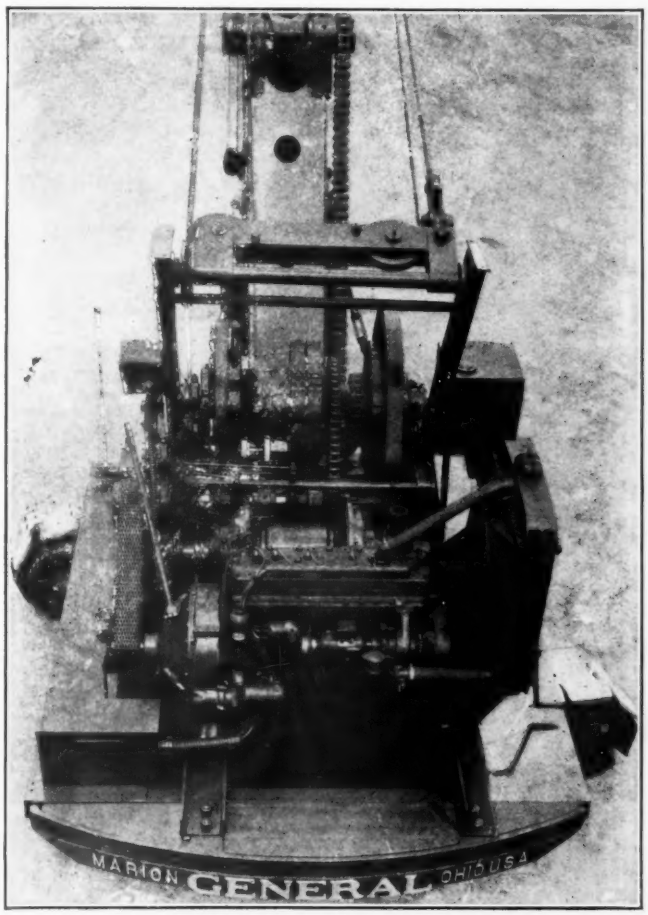
Hoisting or Elevating

The skip hoist is a bucket designed to travel between proper guides, being hoisted from the loading point to the discharge level above the storage bunker by means of cables and a suitable hoist. In the same form, the skip hoist is used for handling ashes.

In smaller plants, bucket elevators are used for elevating, with screw or flight conveyors for horizontal distribution.

One-Level Handling

Tramrail conveyors and traveling weighing larries, which are also used for handling of coal within the boiler room, are very similar to cranes in their design and method of operation. Like the skip hoist, they deliver the materials handled at periodic intervals a certain amount of time being necessary for charging, delivery, and return of the empty carriers.



Courtesy of The General Excavator Company

Fig. 2—Showing the machinery deck of a General shovel. All high speed parts operate in anti-friction bearings. The first reduction is through a silent chain which can be easily adjusted. All other mechanisms, including the engine, are compactly installed and readily accessible.

Lubrication Requirements

A considerable amount of dust is present around any coal-storage yard. In many cases, the operating elements will be exposed to a sufficient extent to permit this to cause serious wear of certain of the moving parts. This will be especially true on some apron, belt, or chain conveyor roll bearings. For this reason, builders today are making special effort to design their equipment of as nearly oil and dust-tight a nature as possible.

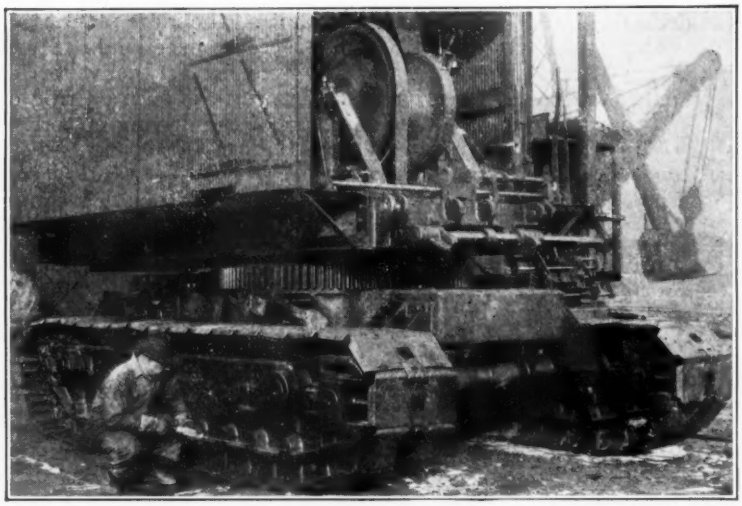
This has rendered it all the more practicable to design for either grease or oil lubrication. Grease is widely preferred for conveyor or roll bearings. Oil, in turn, is used on ring or chain oilers on many of the driving motors.

THE POWER PLANT

Motive power for materials hoisting equipment is derived from a steam engine, a Diesel or gasoline engine, or an electric motor.

The power shovel and railroad crane are generally engine-driven. They are distinctly out-of-door machines. While used extensively

for excavating purposes, they also serve admirably as mobile means for hoisting or transference of ore, coal and steel. In railway service they are the essential means whereby tracklaying and embankment work are expedited.



Courtesy of The Marion Steam Shovel Company

Fig. 3—Lubricating the track rollers on a Marion shovel. The necessary fittings are protected by plugs to keep out dirt and to prevent damage. The massive nature of the turning gear is also indicated.

In the steel yard they may readily be used to supplant the traveling crane in the storing of plates and shapes or the handling of ingot moulds.

Steam Cylinder Lubrication

Lubrication of steam cylinders is a most important item in the maintenance of a steam-power shovel. Under the exposed conditions and methods of operation, if any but a high grade, properly compounded lubricant is used, the cylinders may suffer accordingly.

Steam used on such machines will, in general, be of comparatively low pressure and will have a high moisture content even though the steam is taken from the highest part of the boiler. Furthermore, line condensation between the boiler and engine will increase the moisture content. In addition, there will be a corresponding decrease in pressure, due to the fact that steam pipes are often not covered with sufficient insulation and the engines are usually subject to intermittent operation.

As a result, there will almost always be an accumulation of water above the throttle valves prior to starting the engines, depending in amount upon the length of time they have been stopped. Under such conditions, if the cylinders are not covered with a tenacious film of properly compounded lubricant, this water will tend to wash the lubricant from the contact surfaces, and for the next few strokes insufficient lubrication may prevail.

Operating under these conditions is obviously conducive to wear, loss of compression, and steam blowby past the piston rings, all of which are indicated by noisy operation and groaning. It can largely be corrected, however, by selecting and using a grade of cylinder oil which contains a sufficient amount of high-grade animal or fixed oil to promote the formation of an extremely tenacious film of emulsified lubricant, which will adequately resist the washing action of any water that may be present. The base of this lubricant should be a medium viscosity, highly adhesive, straight mineral stock. For this purpose, a comparatively high compound cylinder oil of about 130 seconds Saybolt viscosity at 210 degrees Fahr., has proven to be very satisfactory.

This should be delivered by a positive feed lubricator, preferably of the mechanical force-feed type, via suitable atomizers. Hydrostatic lubricators could be used, were the engines to operate continually, but the usual intermittent service involved would either require constant closing and opening by the fireman, or else a waste of oil would follow if the lubricator were left in service while the engines were stopped.

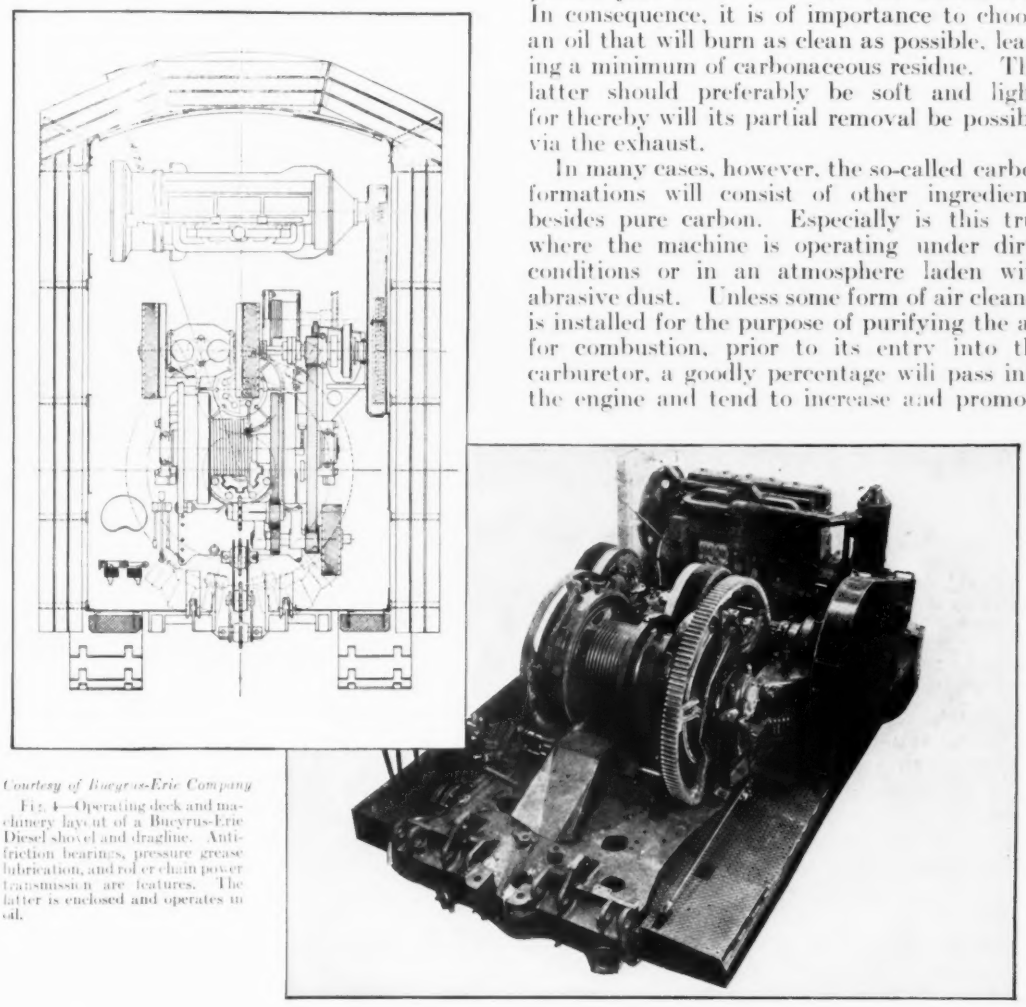
The location of the oil pipes and atomizers in the steam lines is also important. These points should be several feet back from the throttle valves. In cases where a steam thrusting engine is located on the boom in certain types of these machines, the oil line often enters the steam pipe much further back from the throttle. Here steam leaks at the ball or swing joint may also cause considerable loss of oil.

Internal Combustion Engines

With the increase in popularity which attended the perfection of the Diesel and its application to tractor service, it was only logical that it should also be studied as a power medium for the power shovel. In this respect, it paralleled the development of the heavy-duty gasoline engine. Today both are in use in power-shovel service. There is considerable similarity among their lubricating requirements, due to their similarity in design; in

fact, they differ chiefly only in so far as fuel delivery and combustion are concerned.

From the viewpoint of lubrication, we must consider the operating or service conditions, the type of lubricating system, and the procedure in selecting the necessary oils. The degree of satisfaction which will result from the use of any Diesel lubricating oil will depend upon the intensity of the operating conditions. This requires consideration of the prevailing operating temperature range, the possibility of carbonization at high temperatures, the ease of starting at low temperatures, and the working viscosity under full-load operation. The use of a properly refined oil, applied in sufficient amount through a lubricating system which will assure complete coverage of the working parts of the engine, is assurance that the necessary protection will be attained.



Courtesy of Bucyrus-Erie Company

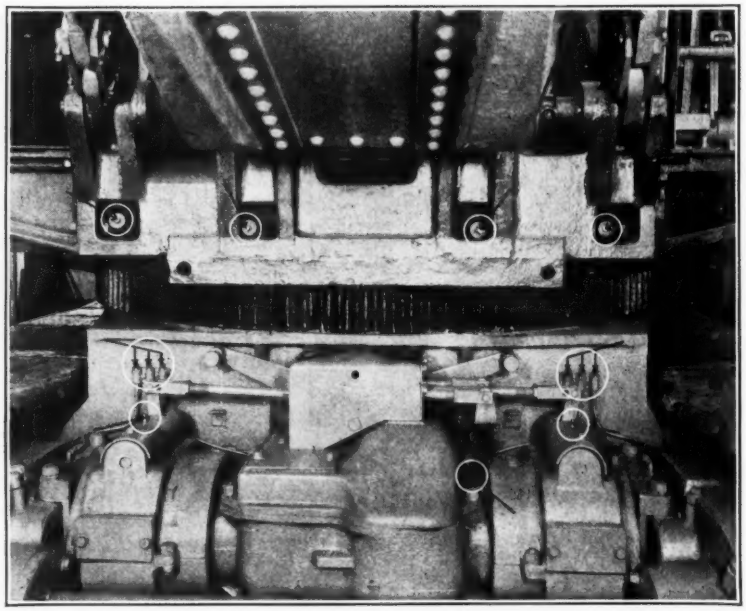
Fig. 4—Operating deck and machinery layout of a Bucyrus-Erie Diesel shovel and dragline. Antifriction bearings, pressure grease lubrication, and roller chain power transmission are features. The latter is enclosed and operates in oil.

Carbonization is one of the most evident indications of the unsuitability of an engine oil during operation. Carbon formations on valves, spark plugs, valve seats, around rings, and in the combustion chamber, hamper the ability of the engine to develop its maximum power, just as is true with the automobile. In consequence, it is of importance to choose an oil that will burn as clean as possible, leaving a minimum of carbonaceous residue. This latter should preferably be soft and light, for thereby will its partial removal be possible via the exhaust.

In many cases, however, the so-called carbon formations will consist of other ingredients besides pure carbon. Especially is this true where the machine is operating under dirty conditions or in an atmosphere laden with abrasive dust. Unless some form of air cleaner is installed for the purpose of purifying the air for combustion, prior to its entry into the carburetor, a goodly percentage will pass into the engine and tend to increase and promote deposits to a marked extent. As a result, an air cleaner is advisable, for its installation will usually insure of better engine performance.

The operating and atmospheric temperatures also are of moment, due to the extent to which the ready starting of the engine may be affected. In this connection, the pour test of the oil is an important characteristic, as it serves as an indication of the ability of the oil to flow under lower temperatures. Wherever these latter may drop below freezing or to within the neighborhood of zero, it is of vital importance to choose an oil of as low a pour test as possible, in order that practically immediate flow will occur to all bearings and cylinders upon start-

ing of the engine. To a certain extent, reduction of the original viscosity may aid in this respect, although there will be a possibility that the ultimate operating viscosity may be rather low.



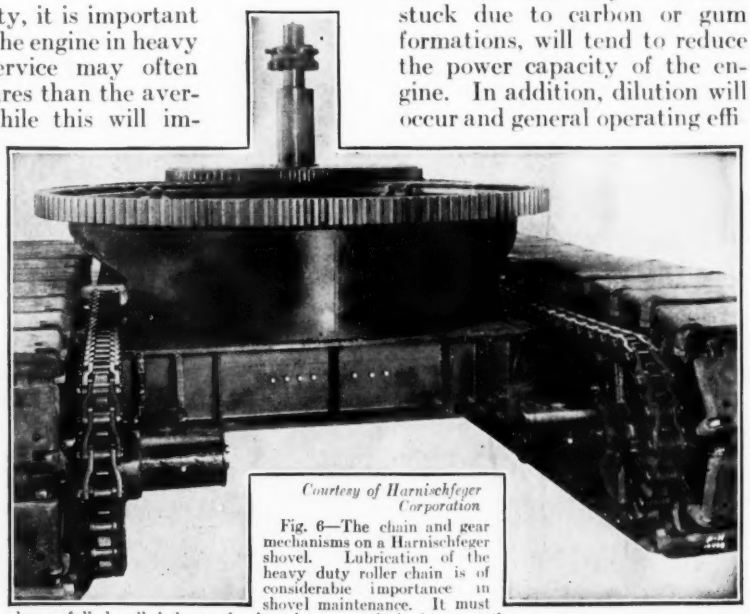
Courtesy of Link-Belt Company

Fig. 5—Link-Belt also provides for extensive grease lubrication of the various bearings. Above is a view directly under the shovel boom on a Link-Belt crawler gas shovel. Circles and arrows indicate the pressure grease fittings. The lower frame gears are enclosed in substantial housings and run in oil.

In connection with viscosity, it is important to note that very frequently the engine in heavy duty materials handling service may often function at higher temperatures than the average automotive engine. While this will improve the combustion of the fuel to some extent, it will also tend to reduce the operating viscosity. On the other hand, higher engine temperatures, with more complete combustion, will reduce the possibility of dilution or the thinning out of the lubricating oil. As a result, there will be but relatively little chance of viscosity reduction by temperature alone being a detriment, provided the lubricating system delivers a sufficient amount of oil to all the contact parts. Where larger sized engines are involved, or where rings may have become worn, a certain increase in normal viscosity will be advisable.

Maximum power becomes possible only where there is maximum compression. While this is chiefly affected by carbon deposits and uneven seating of the valves, we must not overlook the movement of the piston rings in their respective grooves and the extent to which they maintain the requisite seal between the cylinder walls and piston to prevent blowby.

The purpose of these rings is to take care of the more or less variable clearance which practically always exists between the above parts. As a result, these rings must be capable of as free movement as possible. This can only be attained by keeping them free from carbon or gum deposits. Under such conditions, regardless of the age of the engine, or the variation in clearances, if the rings are not abnormally worn and if the oil film is of the requisite body, compression losses will be practically negligible. On the other hand, rings which have worn unevenly or become stuck due to carbon or gum formations, will tend to reduce the power capacity of the engine. In addition, dilution will occur and general operating efficiency will fall off materially. Under such conditions, the substitution of a heavier oil



Courtesy of Harnischfeger Corporation

Fig. 6—The chain and gear mechanisms on a Harnischfeger shovel. Lubrication of the heavy duty roller chain is of considerable importance in shovel maintenance. It must be carefully handled, due to the close clearances which often prevail.

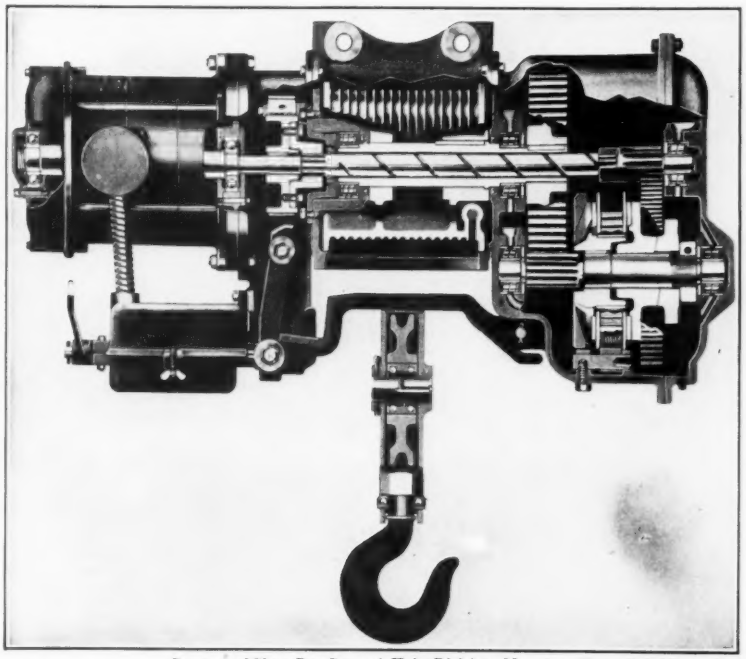
will only serve as a temporary expedient.

Motor Driven Equipment

In contrast with the self-propelled engine-driven machine, the average motor driven crane or hoist will be designed for track operation. It may function under cover or in the open, according to the duty which it is to perform. In the yard it will, of course, be exposed to the weather, but with adequate provision for electric heating of the operating and machinery cab, subsequent difficulties in lubrication should be minimized.

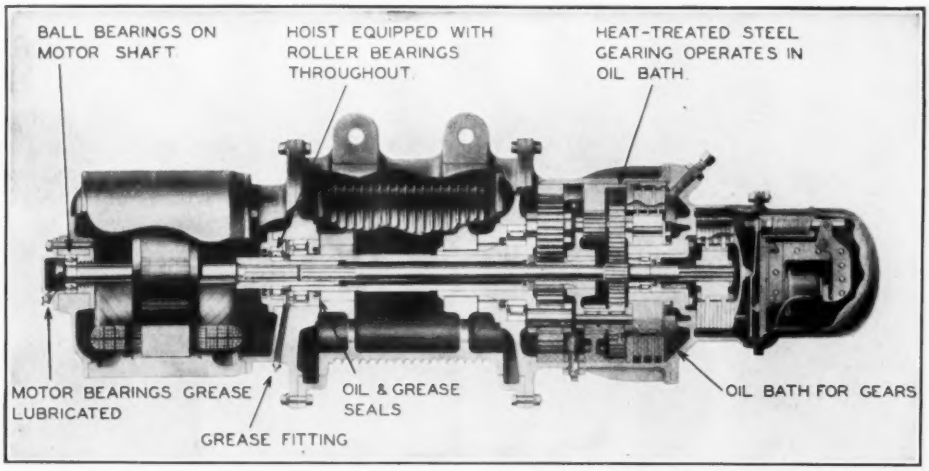
The operating efficiency of such machinery will be largely contingent upon the efficiency of its driving motors. In fact, any failure of the latter to function according to their rating may materially affect those operations which they are intended to maintain.

The efficiency of the electric motor is, in turn, directly dependent upon the efficiency of its lubrication. The motor involves bearings, therefore, require very careful attention to their lubrication. This applies particularly to older types of motors which may not be provided with the necessary guards and baffles



Courtesy of Shaw-Box Crane & Hoist Division; Manning, Maxwell & Moore, Inc.

Fig. 7—A Shaw-Box electric hoist provided for "one point" lubrication. In other words, there is only one place to oil. In this way the bearings and gears are automatically oiled, whenever the hoist is operated, by a combination of splash and force feed lubrication.


BALL BEARINGS ON MOTOR SHAFT
HOIST EQUIPPED WITH ROLLER BEARINGS THROUGHOUT
HEAT-TREATED STEEL GEARING OPERATES IN OIL BATH
MOTOR BEARINGS GREASE LUBRICATED
OIL & GREASE SEALS
OIL BATH FOR GEARS
GREASE FITTING

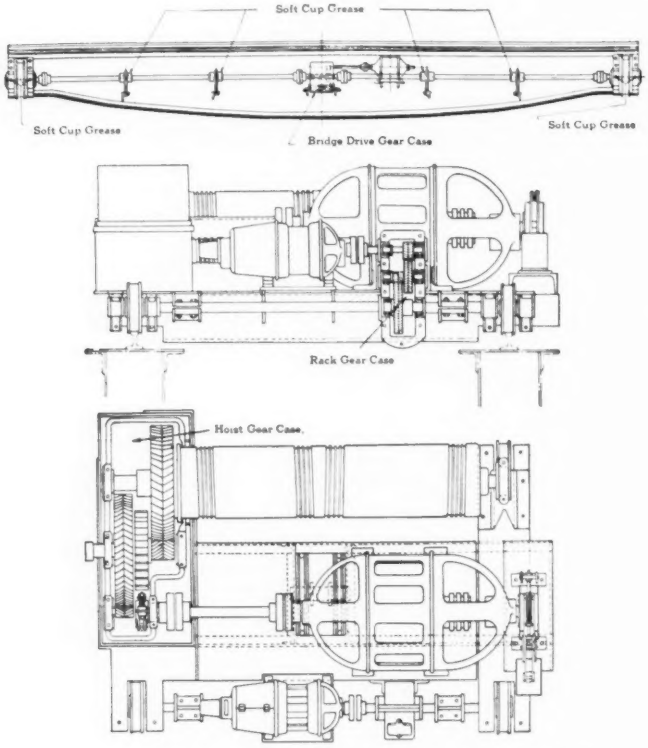
Courtesy of Shepard Niles Crane & Hoist Corporation

Fig. 8—Details of the Shepard Niles "Liftabout" hoist. The fully enclosed nature of this mechanism is a decided adjunct to lubrication. Note the provisions for this latter, using grease for the ball and roller bearings and oil for the gears.

perhaps the most delicate mechanisms to be found in this field of materials handling equipment. Yet it must be capable of operating under most severe conditions. Electric motor to effectively seal the oil reservoirs, etc., against the entry of foreign matter, or to prevent windage from carrying oil into the windings to cause burn-outs.

Motors equipped with ring-oiled bearings will, under average or lower temperature conditions, require an oil of from 180 to 300 seconds Saybolt viscosity at 100 degrees Fahr. To meet the possibility of operation in cold weather, as may be involved in the handling of out-door cranes, ore bridges, etc., this oil should have as low a pour test as possible, to insure against congealment or sluggish flow, which might materially affect circulation of the oil by the rings.

Grease lubricated bearings, in turn, being usually of ball or roller type, require a lubricant specifically prepared for such bearings. As enduring service is necessary, such a grease must resist oil separation, oxidation, breakdown, or hardening. It must not gum, nor develop an acid reaction, and it should be easily applied by the conventional type of pressure gun.

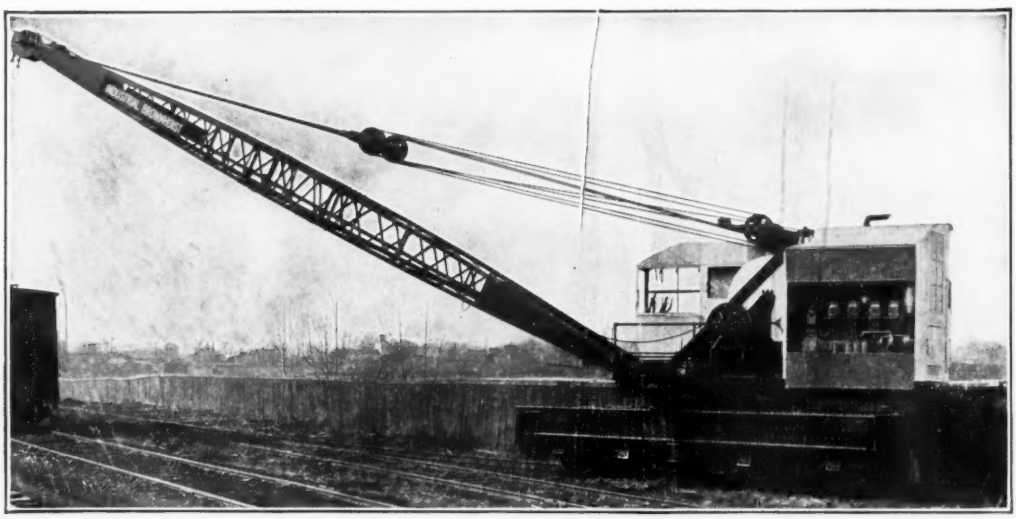


Courtesy of Whiting Corporation

Fig. 9—Details of a Whiting crane showing lubrication recommendations. The use of herringbone gears assures of a pumping action on the oil and flood lubrication of these parts at all times. Frequency of bearing lubrication is based on operating conditions.

WIRE ROPE

Wire rope lubrication is one of the most important factors in any plant where materials in bulk such as ore, coke or coal are to be handled, for the ultimate efficiency of operation is, to a large extent, dependent upon the condition of the cables or wire ropes. Obviously, a rope with one or two broken wires due to drying out, rusting or wear traceable to improper lubrication, may not only cause a tieup of the entire machine if the breaks interfere with the operation of sheaves, or other companion cables, but may also present a distinct hazard. Any wire rope in such condition is just that much weaker and less capable of handling



Courtesy of Industrial Brownhoist Corporation

Fig. 10—A 40-ton Industrial Brownhoist Diesel crane of the railroad type, showing wire rope span and exposed nature of certain of the operating parts.

the imposed loads. Broken wires also increase sheave wear.

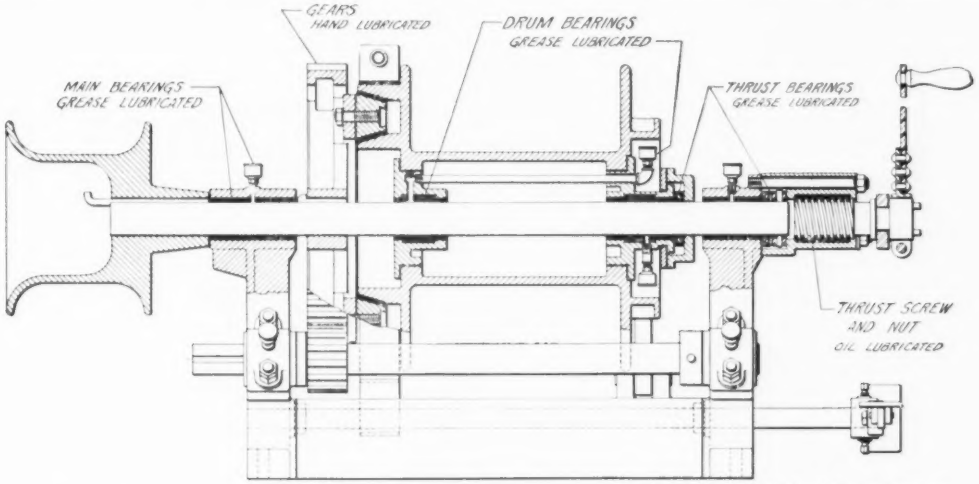
How Friction Occurs

Just because such ropes come from the manufacturers in a thoroughly lubricated state, being in general wound on an oil saturated core, is no assurance that further lubrication is unnecessary. In service there is constant movement between the wires and strands, with a tendency to squeeze out any contained lubricant, especially when the ropes pass over sheaves or around drums. The renewal of this product is, therefore, an absolute necessity, otherwise wear may develop.

Friction between the strands of a wire rope is essentially the same as friction between a bearing and shaft. Overheating and abnormal wear will practically always result, to reduce the load-carrying capacity and increase the amount of power consumed in operation. This can only be overcome by effective lubrication, brought about by the proper application of a suitably prepared wire rope lubricant, which will not only penetrate to the innermost strands and core of the rope, but also will be sufficiently adhesive and viscous to resist being prematurely squeezed out, and later washed off by rain or sleet.

Lubricant Characteristics

In addition to the properties mentioned above, a wire rope lubricant must not tend to cake, gum or ball up, especially if contaminated with an excess of dust, dirt, or metallic particles. Furthermore, it must be resistive to the thinning-down effects of higher temperature. This, of course, directly involves the viscosity or relative fluidity of the product. In fact, viscosity of such products is the essential characteristic involved in purchasing. It should not, however, be assumed as being the chief guide as to the actual suitability of the material. The ability of the lubricant to function, penetrate and stick under actual operating conditions is most important. In consequence, such products should not be purchased haphazardly, nor on a price basis alone. The potential difficulties that might result in cold weather are too serious.



Courtesy of Domestic Engine & Pump Company

Fig. 11—Cross section of a Domestic heavy duty hoist, showing bearing construction and means for pressure grease lubrication.

According to the operating temperatures that may be involved, and the possibility of the presence of an excess of water, the viscosity of a wire rope lubricant should range from 500 to 1000 seconds Saybolt at 210 degrees Fahr. The heavier range is best adapted to warm localities as adjacent to ovens, furnaces, etc., where there might be possibility of the lubricant thinning down to the extent of dripping off to perhaps result in lack of lubrication.

Conversely, under relatively cold conditions as might be involved adjacent to the Great Lakes, in Canada or the Northwest, it would be advisable to use a thinner product, but again in accordance with the range of operating temperatures involved.

Of Petroleum Base

To meet these requirements wire rope lubricants should be straight mineral petroleum products, or of predominately petroleum base, devoid of fillers or thickening mediums. In other words, whatever the viscosity, it should be an inherent property of the lubricant, not an artificial characteristic which may vary widely.

This is why greases or soap thickened mineral

oils are relatively unsuited for wire rope lubrication. To attain the requisite body a comparatively high percentage of soap would be necessary. Soap, of course, serves as the carrying medium for the oil. It has but little lubricating value, however, so that this property in the resultant product is decreased to a marked extent. Furthermore, the adhesive characteristic of greases will usually be too low to meet the requirements of wire rope lubrication.

How the Lubricant is Applied

Wire rope lubricants can best be applied in heated condition and always to dry (moisture-free) rope surfaces. By heating, their body is reduced sufficiently to make them comparatively fluid. By lubricating when the rope is dry of moisture most positive adhesion is assured. This not only protects the rope but decreases the possibility of unfair condemnation of the lubricant. Moisture prevents sticking of the product. To merely attempt to daub or paint a rope with such a product at normal temperatures would be difficult. Even though the surface might be more or less coated, the possibility of penetration occurring to any extent would be remote. This latter is the secret of effective wire rope protection. The amount of wear occurring between the exterior of such a rope and the sheaves is not as marked as that which may occur between adjacent strands when the rope is flexed or bent in passing over sheaves or hoisting drums. On the other hand, *bending promotes penetration of the lubricant.*

A very satisfactory method of treating wire rope is to use a form of split box through which the rope can be run. Such a box can be readily built in the average plant. However, it must be sufficiently tight to prevent the lubricant from leaking out, even when reduced in viscosity by heating, and precaution must always be taken to see that no moisture is present. Also be sure that the rope surface is moisture-dry.

The slow passage of the rope through such a bath of heated lubricant will insure not only that the surface will be coated, but also that the requisite penetration to the inner strands takes place. Slow working of the rope over the sheaves before the lubricant has time to cool completely will then aid in bringing about the maximum of penetration.

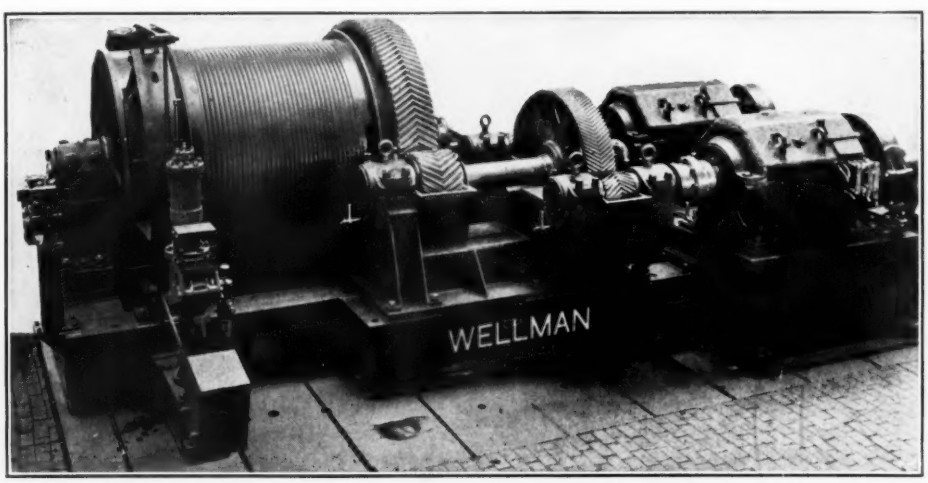
Drip lubrication is also practicable on many rope installations, a fairly light gear lubricant being allowed to drip from a container overhead on to the rope. The comparative fluidity of the lubricant facilitates penetration; surface protection also is increased by the lubricant thereon becoming mixed with dust or dirt to develop a protective coating.

GEAR DRIVES

Gear lubrication on hoisting equipment must be studied wherever the gears may operate exposed to the elements or in an atmosphere of dust and dirt.

There are certain definite properties which a gear lubricant should possess if it is to function effectively, viz.:

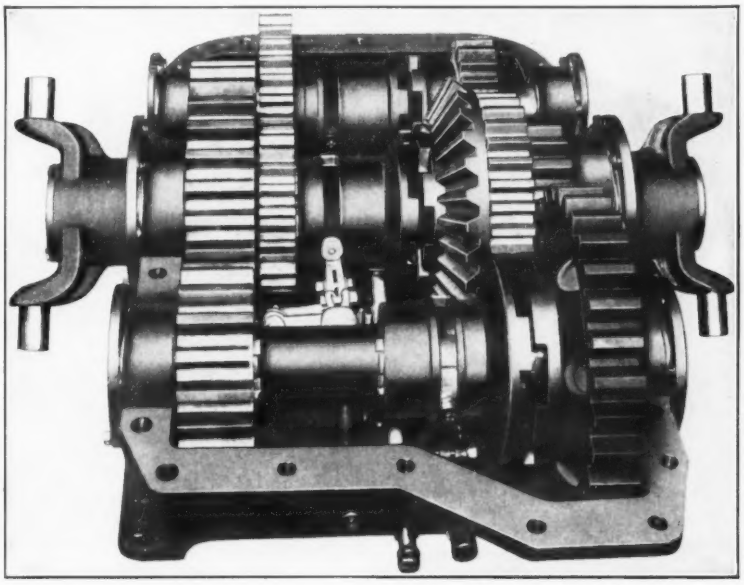
1. Sufficient lubricating ability or "oiliness" to insure of maximum reduction of both solid and fluid friction.
2. A viscosity commensurate with the method of lubrication and the amount of



Courtesy of The Wellman Engineering Company

Fig. 12—Showing a Wellman skiphoist with gear covers removed. Note the use of herringbone gears.

heat that may be encountered, so that a suitable film will be insured between the teeth as they become enmeshed, to resist the effects of both pressure and temperature. Pressure exerts a squeezing-out action; temperature affects the fluidity. In other words, viscosity is reduced as temperature rises, and vice versa.



Courtesy of American Hoist & Derrick Company

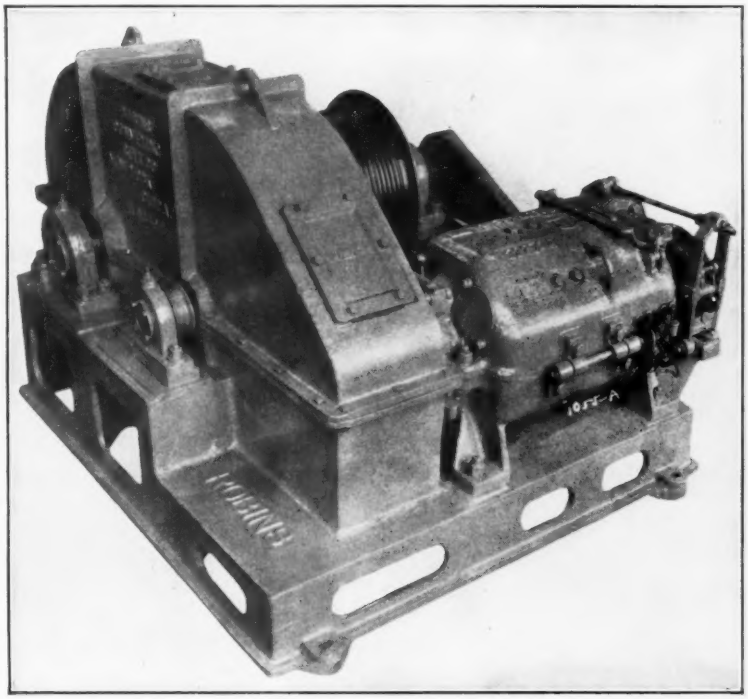
Fig. 13—The American Three Speed Crane Transmission, showing gear assembly. This mechanism operates in a dustproof oiltight housing, and is constantly lubricated.

3. Sufficient adhesiveness so that when used under exposed or semi-enclosed conditions, an adequate film will remain on the teeth to resist the throw-off effect of centrifugal force.

4. The least possible tendency to congeal, harden, crack, or become brittle when used under low temperature conditions, or to carbonize and chip if exposed to abnormally high temperatures.

Pressure is a most important item in a gear installation. As a rule, tooth pressures will be high, and the bearing surfaces, due to their relatively small areas of contact, will carry heavy loads. The more carefully and accurately the gears have been cut, the more intense will be these pressures, inasmuch as line contacts will more nearly exist. Furthermore, this line of contact or pressure will be constantly changing as the gear teeth pass in and out of mesh. This changes the direction of application of the load.

As long as rolling motion predominates, the effect of the above on the structure of the teeth will not be serious. But once wear has begun to take place, sliding motion will supplant rolling motion to a proportional extent, and grinding of the surfaces will result. This explains the more or less rapidity with which gear teeth will become worn down wherever their lubrication is neglected.



Courtesy of Robins Conveying Belt Company

Fig. 14—A Robins standard skiphoist unit, showing nature of housing to protect lubrication.

Petroleum Base Lubricants Best

A straight mineral product will most generally possess the characteristics outlined above. With the exception of instances involving both gear and bearing lubrication, the viscosity of such a lubricant should be relatively high. In other words, it should vary from perhaps 100 seconds to 1000 seconds Saybolt at 210 degrees Fahr. This is a wide range, but we are confronted with a wide range of operating conditions and constructional requirements. Classified in accordance with the types of gears involved, the viscosity range will fall within reasonable limits.

Methods of Gear Lubrication

Gear lubrication can be grouped into four classifications or conditions which will be indicative of the manner in which it can be most effectively carried out, according to the service, location, housing, and function of the gears, i.e.:

1. Where an oil-tight casing or housing is employed, the gears therein being capable of lubrication apart from their shaft bearings. This is in effect the most ideal condition, for it facilitates the use of a lubricant of just the right viscosity to withstand such pressures and temperatures as may be involved. As a rule, bath, pressure, or splash lubrication will be applicable. Where the former is used, a somewhat heavier product may be advisable than where the lubricant is forced or splashed onto the teeth under a certain amount of pressure. With a force-feed system, the oil is usually delivered to the teeth just before they pass into mesh.
2. In many cases, however, the gears will be so enclosed, but, in addition, their bearings will have to be lubricated by the same lubricant. Here a compromise is necessary. In other words, a product sufficiently fluid to serve the bearings and yet viscous and adhesive enough to maintain a satisfactory film on the gear teeth should be used. Worm reduction gears are typical examples of the above. Here ball or roller bearings frequently present another point for consideration, wherever they are contained within the case. Here a lubricant of steam cylinder oil characteristics is often desirable.
3. But all gears are not enclosed. Frequently they will be entirely exposed. Here the lubricant must usually be applied by hand. So a highly viscous product will be necessary. As a rule, a viscosity of about 1000 seconds Saybolt at 210 degrees Fahr., will best resist the effects of weather, centrifugal force, and the usual dusty or dirt conditions which may be involved. It will remain the longest on the teeth, thereby requiring but relatively infrequent renewals.
4. In other instances, exposed gears will operate with their lower portion partially enclosed in an oil-tight pan which will permit of bath lubrication. This affords relatively automatic lubrication, though, of course, it is necessary to keep the level of the lubricant as low as possible to prevent splashing or throwing, especially if the gears are run at higher speed.

   Good practice dictates usually that the lowermost teeth of the lower gear shall just dip into the lubricant, provided, of course, that the latter is of the requisite viscosity and tenacity to adhere sufficiently to the teeth to be carried and, in turn, distributed to the teeth of such other gears as may be involved in these trains. Under slower speed conditions, a lubricant of about 200 seconds Saybolt viscosity will meet these requirements. Where speeds are higher, however, or temperatures excessive, it may be advisable to use a heavier product of about 1000 seconds Saybolt viscosity at 210 degrees Fahr.

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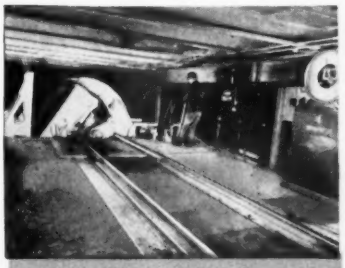
The D. O. CLARK MINE in its SECOND YEAR

700-TON-PER-HOUR railroad fuel tipple, showing conveyor gallery from mine mouth.



TYPICAL UNDERGROUND dump station, car in rotary dump.

48-INCH CONVEYOR in gallery of D. O. Clark Mine, Superior, Wyo.

DRIVE HOUSE CONVEYOR, motor, magnetic thruster brake, speed reducer, drive and pulleys.

SHAKER SCREENS in tipple, showing also the magnetic pulley for separating out tramp iron.

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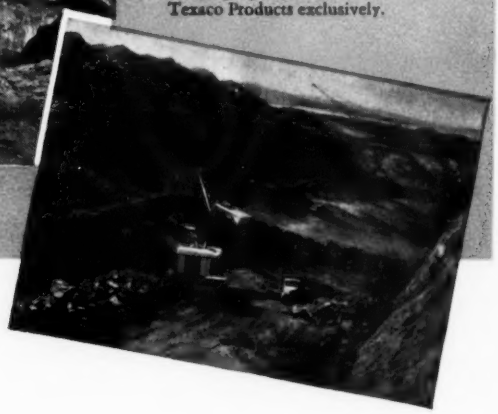

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